Development of a Turn Key Cryogenic Cooling Module for Space Flight Based on a Commercial Cryocooler

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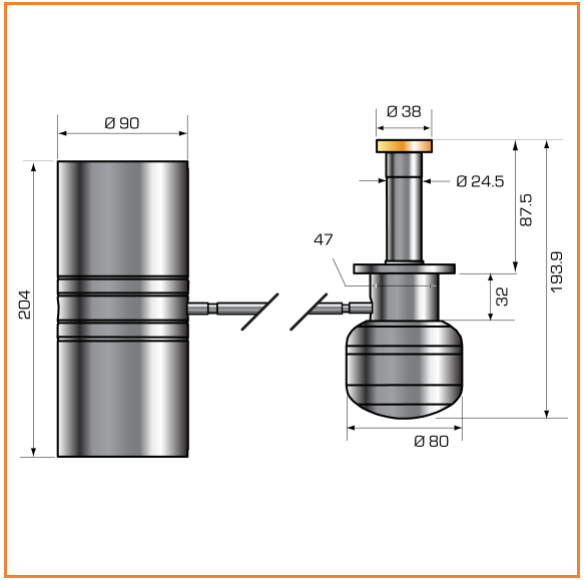
Objective: Adapt COTS Cooler for Flight

- COTS coolers have significant advantages
  - Procurement cost
  - Lead time
  - Experience base
- But some problems must be solved
  - Heat rejection
  - Launch loads
  - Electronics
  - Peripherals

Core is Thales 9310

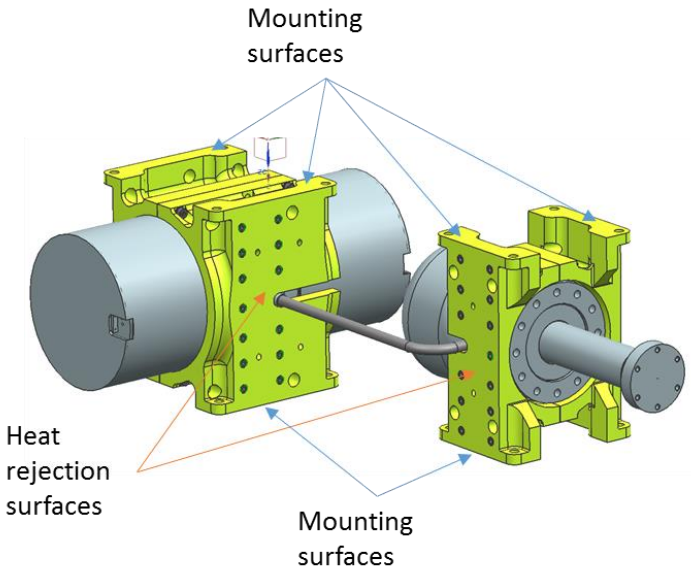
- 5 W class pulse tube
- High production rate
- 47 Hz operating frequency
- Suitable for ground use, lacks features needed for flight



Source: http://www.thales-cryogenics.com/wp-content/uploads/2014/04/lpt9310weboutline.png

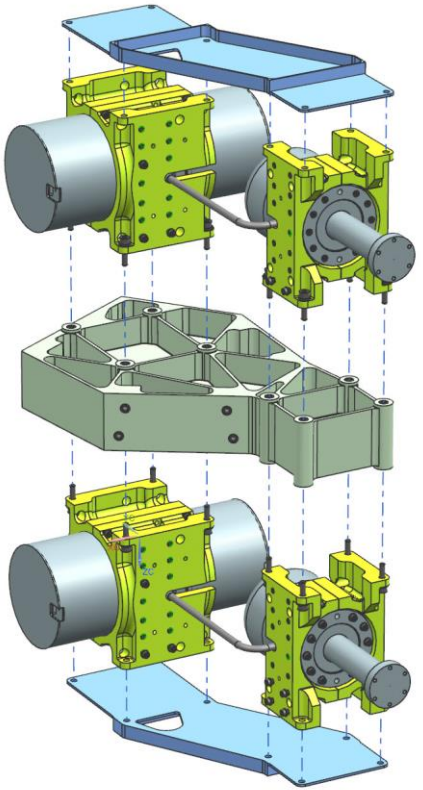
Mounting Blocks Provide Heat Rejection

- Aluminum
- Structural support
- Provide interface for CCHPs
  - Compressor and expander require cooling
  - Two per component for one fault tolerance



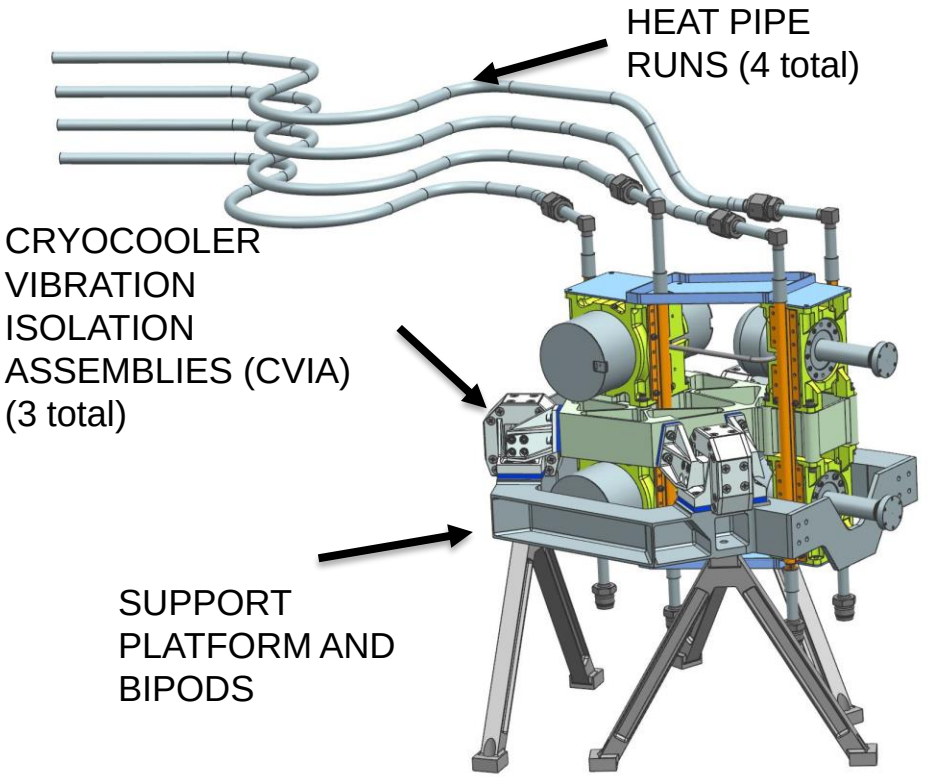
Rigid Support for Two Coolers

- Aluminum
- Structural support
- First mode above 3rd harmonic
- Avoid amplification of inputs



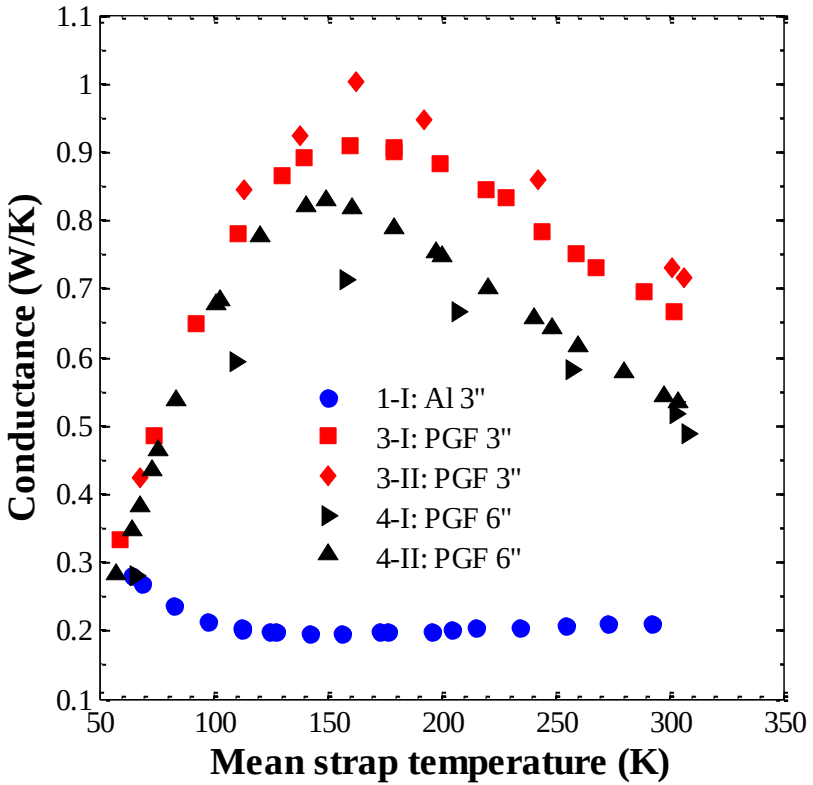
Full Assembly Includes Passive Vibration Damping

- Visco-elastic isolators from Moog-CSA
- Modes ~20-30 Hz
- Damps launch loads and operating EFT
- Coolers export vibe in pulse tube and other direction
- AVC only works in compressor direction



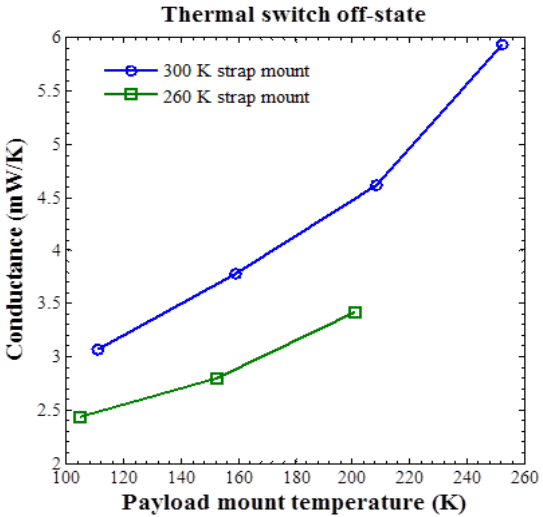
Straps Connect Cooler to Payload

- Thermotive LLC
- Composite foil conductors
- Significantly better conductance than aluminum
- Has passed large displacement dynamic testing



Thermal Switches Disconnect Redundant Cooler

- Built by Orbital ATK
- Modification of existing design
  - Differential CTE



See: Bugby, D. C., et al., “Cryogenic Thermal Management Advanced During the Cryotool Program”, in Advances in Cryogenic Engineering Vol. 51, J. G. Weisend II, ed., October 2006

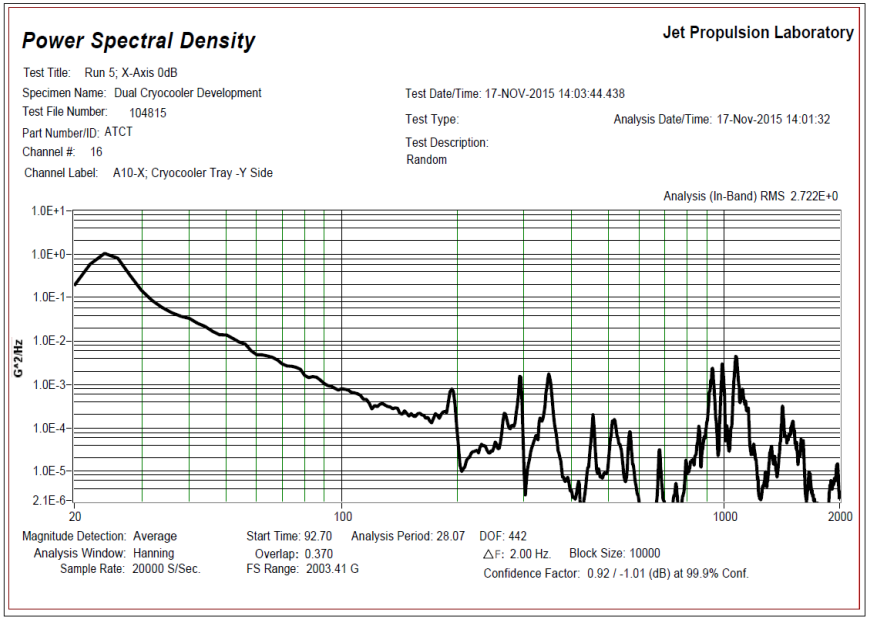
Modified Iris LCCE Electronics

- Iris Technology is producing a line of cryocooler electronics
- Modifying LCCE
  - 200 W output
  - Active vibe cancellation to 5th harmonic
- Brassboard and EM have been produced

Passed Launch Vibe

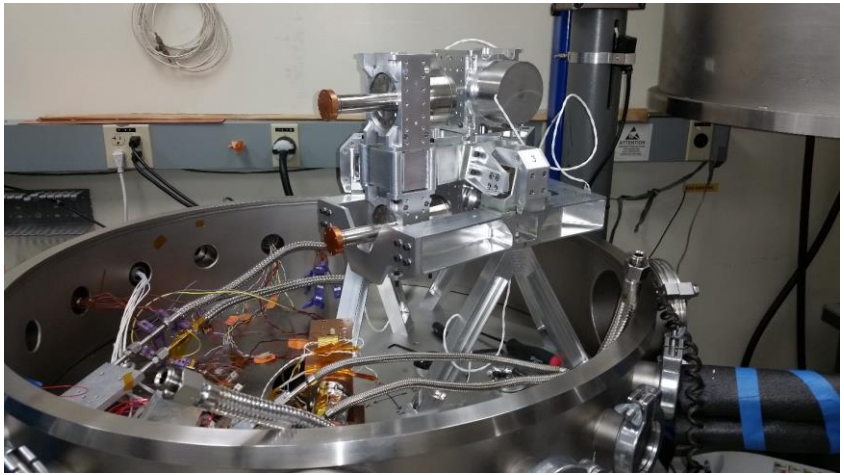
- Tested to a generic random launch vibe profile
- Good roll off of 2nd and 3rd harmonic EFT

Frequency (Hz)	Protoflight Test Level
20	0.026 g^2/Hz
20-50	+6 dB/octave
50-500	0.16 g^2/Hz
500-2000	-4.5 dB/octave
2000	0.02
G_{rms} overall	12.4 g^2/Hz
Test duration is 60 seconds per axis	



Fully Assembled Unit Ready for Thermal Test

- Have run EMI
  - Pass with some small outages
- Running Exported Forces and Torques (EFT) now



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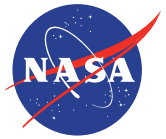

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